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ON THE POSSIBILITY OF OBTAINING EFFICIENT CERAMIC PRODUCTS BASED ON SUBSTANDARD CLAYS OF THE REPUBLIC OF KARAKALPAKSTAN USING CHOPPED COTTON STALKS (GUZAPAYA) AS A BURNING ADDITIVE

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ABSTRACT

This article presents the results of a complex of experimental and theoretical studies to substantiate the possibility of obtaining effective ceramic products based on substandard clays of the Republic of Karakalpakstan using chopped cotton stalks as a burning additive. Conducting pilot production work on the introduction of the developed compositions and technology to obtain wall ceramic products, products with the following property indices were obtained: density 1000-1200 kg/m3, compressive strength 8.5-10.5 MPa and thermal conductivity 0.2- 0.3 W/m•0C.

KEYWORDS: Ceramic Products, Clays, Local Raw Materials, Clay Mass, Burning Additive, Drying, Firing, Agricultural Waste & Cotton Stalks

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Original Article

INTRODUCTION

The development of the building materials production on a modern scale requires the involvement of large volumes of raw materials and supplies in the economic turnover. The depletion of raw materials observed in recent years makes it necessary to find the possibility of obtaining products from industrial waste at minimal cost. Therefore, one of the important directions in the development of the national economy of the Republic of Uzbekistan, especially in the context of the transition to a market economy, is the maximum use of secondary resources [1–4].

According to the existing enlarged classification, agricultural waste (AW) includes agricultural waste, such as straw, stalks of corn, sunflower, cotton stalks (guzapaya), tobacco, sunflower baskets, cut branches of fruit trees, vines, etc.

AW can serve as a renewable source of raw materials for the manufacture of building materials for enclosing structures. An increase in the volume of their use will not only provide construction with additional raw materials and expand the range of local building materials and products but will contribute to the conservation and rational use of natural materials, which is also an important environmental task, the solution of which will greatly contribute to the improvement of the environment, save fuel and energy resources, capital investments, transportation costs and will ensure a reduction in the cost of products [5–8].

In areas oriented to the production of agricultural products, a large amount of plant waste remains after the processing of grain crops and cotton. In particular, over 500 thousand tons of cotton stalks are accumulated

annually in the Republic of Karakalpakstan, about 60% of which are used by local residents as fuel. Specialists have established that over 150 thousand tons of guzapaya, which remain unused annually, under their complex processing, can replace 300-320 thousand m^3 of commercial timber imported to the Republic of Karakalpakstan.

In world practice, the main methods of waste disposal are their burial, use as fertilizers in agriculture, thermal processing (burning and pyrolysis). The share of used secondary raw materials in the production of building materials is insignificant. Slow development of AW is due to insufficient research on both the raw materials themselves and the physicochemical processes occurring in the compositions of ceramic masses during heat treatment.

Given the ever-growing need for building enclosing structures, in particular for the needs of agriculture, as well as in connection with the preparation of a long-term comprehensive program for solving environmental problems in the Republic of Karakalpakstan, environmental measures were determined to improve the environment. As part of the implementation of these programs, the relevance of using AW is even higher. Below are the methods for utilizing guzapaya (Figure. 1).

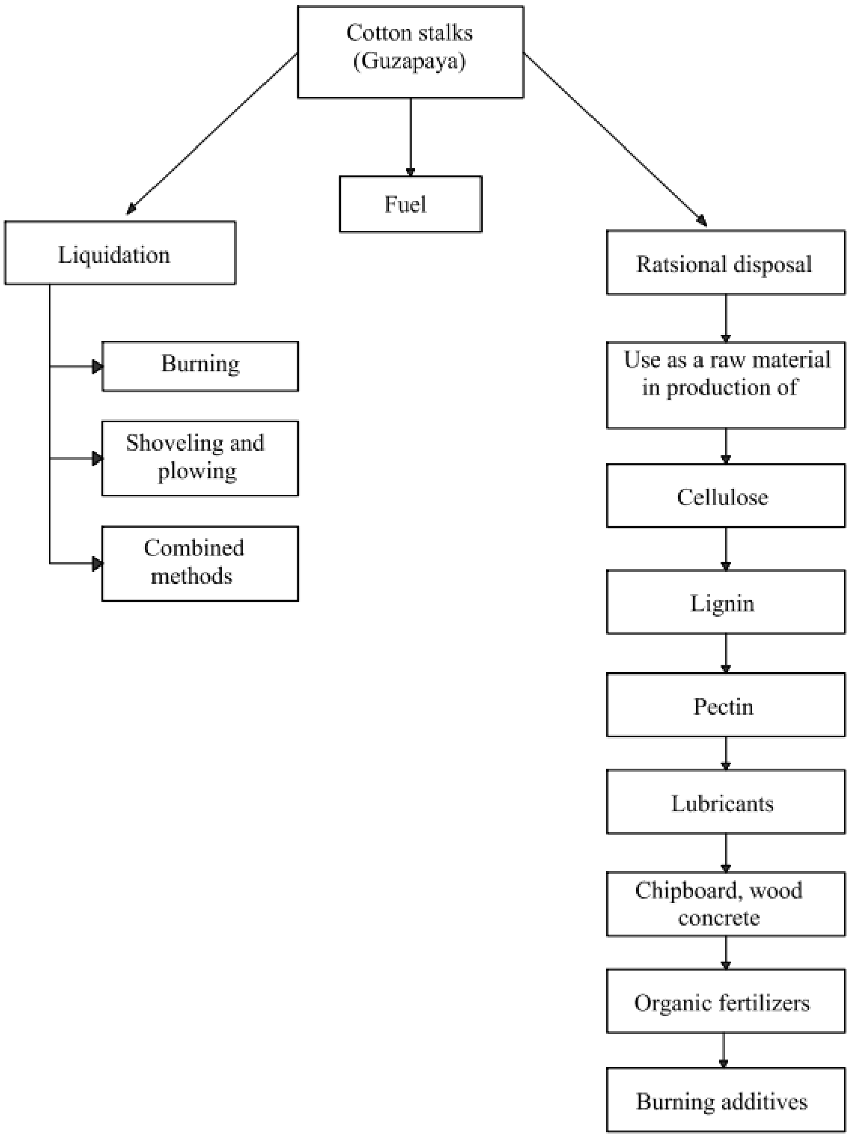

Figure 1: Guzapaya Disposal Methods.

As the analysis of literary sources has shown, studies on the use of coal mining waste, sawdust, shavings, etc. as burnable additives in the technology of wall ceramics were thoroughly worked out. It should also be noted that for the production of products based on them, mainly clays were used as they met the requirements of the relevant standards of GOST in terms of mineralogical and chemical composition. The manufacturing of ceramic materials based on substandard clays using AW (guzapaya) as burnable additives for the Republic of Karakalpakstan remains poorly studied. To implement this task, the authors conducted a set of theoretical and experimental studies to substantiate the possibility of producing effective wall ceramic products based on low-quality clays and AW [9–12].

The relevance of research is confirmed by the fact that thirty clay deposits for the production of ceramic products are located on the territory of the Republic of Karakalpakstan, and only 11 of them are suitable for the production of bricks and tiles in their natural state. Loesses, loams of other deposits are used in a mixture with kaolin or bentonite clays.

METHODS

To determine the suitability of substandard clay raw materials, at the first stage, comprehensive studies were conducted to assess the quality indices of clays, their mineralogical, petrographic and chemical composition. Based on the results of the analysis of clays from the Nukus and Bestyubinsk deposits (Tables 1 and 2), it was determined that the main non-clay minerals in the samples are quartz (4.26-3.34-1.817Å), calcite (3.86-3.04 -2.50-2.09Å), feldspars-potassium feldspar (3.80-3.24-2.16Å), in the first sample, presumably, amphibole (8.29-2.72-2.87Å), gypsum (7.65) and in the second sample - pyrite (2.70-1.63Å).

Table 1: X-Ray-Diffraction Analysis of Original Samples of Clays from Different Deposits

Sample No.	Sample Site	Content of Main Rock-Forming Minerals, %									Crystal-Chemical Characteristics of Clay Minerals
		Clayey		Carbon-iferous		Other		Total			
		Hydromica	Chlorite	Calcite	Marl limestone;	Quartz	Albite, etc.	Clayey	Carboniferous	Other	
1	Nukus region	36	20	11	3	14	17	56	13	31	31 Serici-te+Hydromica muscovite type, SGM (<40), Ca-Mg-Montmorillonite
2	Best-yubinsk deposit	29	18	13	4	21	15	47	17	36	Sericite, Ca-Mg-Montmorillonite

Table 2: Results of X-Ray-Diffraction Analysis of Clay Fraction

Sample No.	Total content of clay minerals in the original sample	Content of Clay Phases				Other min-erals
		Hydromica	Chlorite	Kaolinite	Smectite	
1	55,7	66,1	24,5	0	9,4	Calcite, quartz
2	47,2	69,8	18,3	0	11,9	quartz

The content of clay minerals (layered aluminosilicates) in the original samples is 47.2-55.7%. Micaceous minerals, represented in sample No. 1 by sericite and hydro micas with mixed-layer formation, dominate in their composition. They contain less than 40% of swellable layers in sample 2 with sericite. The samples also contain ferruginous-magnesium chlorites. Montmorillonites were not found in the original composition.

The study of the composition of the fine-dispersed fraction of the samples showed the presence of hydro micas (66.1-69.8%), chlorites (18.3-24.5%), montmorillonite 9.4-11.9% in their composition. Along with clay minerals, the presence of quartz and calcite was observed.

Let us analyze the influence of the mineral composition of the studied soil samples on the nature of the ceramic body formation. As is well known, quartz, the most common admixture of most clays, enter their composition in an amount from a few percent to 60% or more. Quartz impurities reduce the plasticity and binding ability of clay, thereby worsening the molding properties. Fine-grained quartz dust (shlyuf) greatly increases the sensitivity of clays to drying. Coarse quartz sand improves the drying properties of clays, reduces their shrinkage during drying, and therefore is a desirable component in the production of bricks. When firing up to 1000-1100^{0}C, quartz does not enter into chemical reactions, undergoing only modification transformations. At 1200^{0}C and higher, quartz, dissolving in silicate melts, significantly changes their properties; it increases viscosity, refractoriness, and reduces thermal expansion. When cooling products due to irreversible polymorphic transformations, it leads to volumetric changes. According to the amount of free quartz, clay raw materials are divided into three groups: of low (10%), medium (10-25%) and high (over 25%) content [13].

Calcium and magnesium carbonates are often found in clays, especially in low-quality ones, their amount can reach 25-30%. Fine impurities of carbonates, decomposing during firing to oxides, increase the porosity of products and somewhat reduce their strength (for bricks, drainage pipes, the first is not harmful, and even desirable for facing tiles). At higher firing temperatures (above 1000^{0}C), calcium and magnesium oxides, acting as strong flux flows, form low-viscosity melts, which can cause product deformation. Large inclusions of carbonates are especially harmful, since, not having time to react with clay and other minerals during firing, they remain after firing in the form of oxides that absorb water from the atmosphere, form hydroxides and, increasing in volume, can destroy the product (a defect, called "dutik"). Generally, carbonates reduce refractoriness and sintering interval [13].

Dolomite is a sedimentary rock composed primarily of the dolomite mineral [$CaMg(CO_3)_2$]. Dolomites with significant admixtures of calcite (over 50%) are called dolomitic limestones. In nature, dolomite occurs in the form of coarse (> 0.25 mm), medium (0.1–0.25 mm) and fine-crystalline (<0.1 mm) aggregates [13].

Montmorillonite is the main constituent of bentonite clays. The main structural motif is 2:1 type packages with weak van der Waals forces between each other, which explains the perfect cleavage, easy splitting into thin scales and the peculiar soapiness of bentonite clays when rubbed with fingers. Octahedral layers can contain both aluminum ions and magnesium ions. Isomorphic substitutions are also characteristic of the tetrahedral sublattice, which contains montmorillonite in the structure and acts as electrostatic compensators for the negative charge of the package that arises during isomorphic substitutions (in addition to Na^+ there can be K^+, Ca^{2+}, Mg^{2+}). These cations are capable of exchange; in the aquatic environment, they are hydrated. Depending on the air humidity and the type of interpackage cation, there can be a different number of water molecules (nH_2O) between the packages, therefore the interpackage distance of montmorillonite ranges from 0.95 to 1.9 nm and the crystal lattice of montmorillonite is able to swell. Montmorrilonite occurs mainly in the form of equal-sized lamellar fine particles (about 30 nm in diameter), usually with irregular edges,

they are prone to sticking together and swelling in water. Montmorillonite imparts to bentonite clays high sorption properties, plasticity, and the ability to swell when moistened [13].

Chlorite $[Mg_{6-x-y}Fe^{2+}{}_{y}Al_{x}(Si_{4-x})O_{10}(OH)_{8}]$ is a mica-like mineral, consisting of alternating mica and brucite-like layers (tetraform package of 2:1:1 type). Chlorite minerals are predominantly trioctahedral, sometimes dioctahedral. Due to the nature of the bond within and between the packages, chlorites usually do not swell in water. Clayey chlorites are fine-grained and relatively poorly crystallized. They are always found mixed with other clay minerals. In particle size, chlorites are similar to illite clay minerals [13].

Considering the above materials on the influence of the mineralogical composition of the original clays on the formation of a ceramic body, studies were carried out at the second stage on the development of technological modes for producing ceramic products. The process of manufacturing ceramic bricks using guzapaya as a burnable additive consists of the following technological operations (Fig. 2): preparation of guzapaya (chopping), clay (rough and fine processing), dosage and mixing of components (clay, guzapaya, water) in a mixer. Then - molding in an extruder, beam cutting, drying and firing. During the firing process, guzapaya burns out in a reducing agent, resulting in the formation of a brick with a highly porous structure and, accordingly, with a loss of strength.

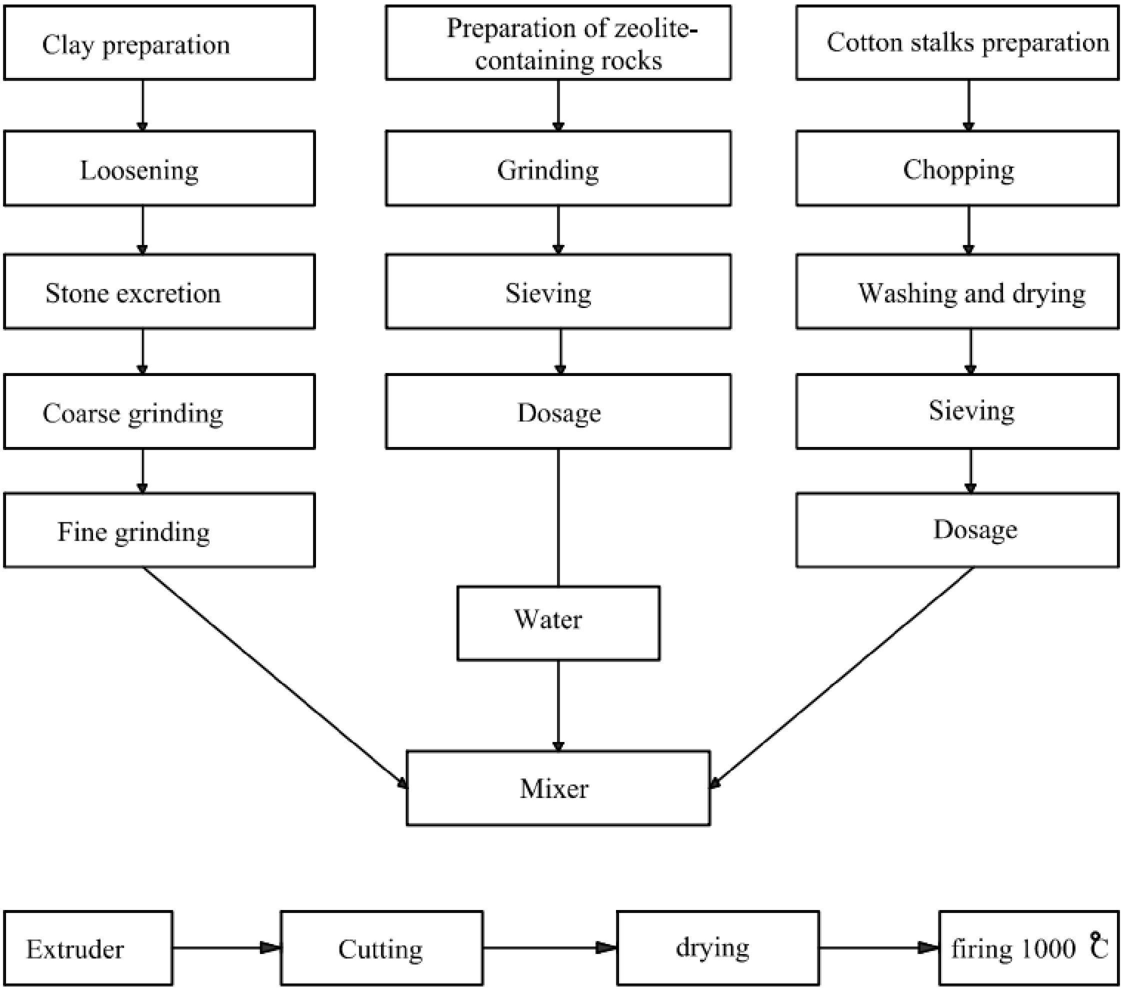

Figure 2: Technological Scheme for Obtaining Effective Ceramic Products using local Raw Materials.

According to the developed technology, it is planned to introduce the prepared guzapaya as a burning additive into the clay composition, followed by firing according to the established temperature regime.

At the third stage, the influence of the content of chopped cotton stalks on the technological properties of the clay mass, the physical, mechanical and operational properties of the ceramic body were studied.

DISCUSSIONS

Studies of the technological properties of the clay mass showed that with an increase in the content of the additive of cotton stalks from 3 to 15% by weight of clay, the molding moisture content of the ceramic mass increases from 17 to 22%, and in the case of using a corrective additive from zeolite-containing rocks from the Beltau deposit, it increased to 24%. As a result of an increase in the molding moisture content of the clay composition, already after drying, the density of the samples significantly decreases, the porosity increases, and the shrinkage remains unchanged. During the firing process, the porosity of samples with the addition of cotton stalks increases even more due to gas formation during combustion.

Studies of the physico-mechanical and operational properties of the ceramic composition also showed positive results, the main of which are given in Table 3.

Table 3: Comparative Characteristics of Ceramic Compositions with the Addition of Cotton Stalks and Zeolite-Containing Rocks from 5 to 15%

Name of Clay	Average Density, kg/m^3	$R_{сж}$ MPa	Water Absorption %
Loess-like loam	1675	17,48	20,7
Loess-like loam + zeolite-bearing rock + cotton stalks (5%)	1272	13	26,91
Loess-like loam + zeolite-bearing rock + cotton stalks (10%)	1046	8,25	33,24
Loess-like loam + zeolite-bearing rock + cotton stalks (15%)	0,880	6,63	41,37

CONCLUSIONS

Thus, the studies conducted substantiated the possibility of producing effective wall ceramic products based on low-quality clays of the Republic of Karakalpakstan. In particular, with the optimal values of the recipe-technological parameters of the ceramic mass at two brick factories in Nukus (LLC "QIZKETKENKIRPICH" and LLC "ETALONKIRPICH"), effective wall ceramics were produced from loess-like loams of the Bestyubensk deposit with the addition of zeolite-containing rocks from the Beltau deposit and copped cotton stalks. The product was obtained with the following properties: density 1000-1200 kg/m^3, compressive strength 8.5-10.5 MPa and thermal conductivity 0.2-0.3 W/m·^{0}C.

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